

THE ENTOMOLOGY OF HOOKE AND LEEUVENHOEK

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ROBERT HOOKE

(1635-1703)

When Robert Hooke was making his contributions to human knowledge, London was a walled city, with gates locked at night and with bellmen calling the hour and weather all through the night. Although it was a frivolous and drinking age, Hooke's versatility did not embrace the lighter activities of his time. An Oxford graduate, professor of geometry, one-time city surveyor, fellow of the Royal Society and secretary from 1677 to 1682, inventor, and author, his energies were distributed in such fields as physics, architecture, chemistry, mathematics, philosophy, astronomy and microscopy. Grotesque and small in physique, unkempt in appearance, irascible, offensively argumentative, arrogant, melancholy, incredulous, stingy, invidious and with jaundiced eye, he was not loved by his contemporaries. Nevertheless his mind was able and prolific, and to it we owe the balance wheel of watches, many inventions, improvements in astronomical and physical instruments, and observations anticipating the work of others in optics and gravitation. Hooke started much more than he finished and, with all his other interests, he dipped also into the field of zoology, including entomology.

Hooke was more of a microscopist than an entomologist, and his observations on insects were incidental to his interest in the microscope, the invention and improvement of which had opened up a big field for students of detail. He stuck all sorts of things under his lenses—watered silks, sand, seaweed, the edge of a razor, poppy seeds, the feet, head and wings of flies, ants, bookworms, lice, mites, fleas, spiders, glass, sponge, cork, charcoal, etc.—and his observations were published in London by the

Royal Society in 1665 under the title, "Micrographia or some Physiological Descriptions of Minute Bodies made by Magnifying Glasses, with Observations and Inquiries thereupon."

In the preface to his work, Hooke says, "It is the great prerogative of Mankind above other Creatures, that we are not only able to *behold* the works of Nature, or barely to *sustain* our lives by them, but we have also the power of *considering, comparing, altering, assisting, and improving* them to various uses. And as this is the peculiar privilege of humane Nature in general, so is it capable of being so far advanced by the helps of Art, and Experience, as to make some Men excel others in their Observations, and Deductions, almost as much as they do Beasts. By the addition of such *artificial Instruments and methods*, there may be, in some manner, a reparation made for the mischiefs, and imperfection, mankind has drawn upon it self, by negligence, and intemperance, and a wilful and superstitious deserting the Prescripts and Rules of Nature, whereby every man, both from a deriv'd corruption, innate and born with him, and from his breeding and converse with men, is very subject to slip into all sorts of errors."

Altogether sixty observations are listed by Hooke, and many of them are accompanied by large black and white drawings said to have been made by the author. Nineteen observations refer to parts of insects, entire insects or related creatures, and the titles of these (omitting observations 47 and 48, on spiders) are as follows: "Obser. 37. Of the Feet of Flyes and other Insects"; 38, "Of the Wings of Flyes"; 39, "Of the Head of a Fly"; 41, "Of the Eggs of Silkworms"; 42, "Of a blue Fly"; 43, "Of a water Insect"; 44, "Of the tufted Gnat"; 45, "Of the great belly'd Gnat"; 46, "Of a white moth"; 49, "Of an Ant"; 50, "Of the wandring Mite"; 51, "Of a Crab-like Insect"; 52, "Of a Book-worm"; 53, "Of a Flea"; 54, "Of a Louse"; 55, "Of Mites"; 56, "Of small Vine-Mites."

"Of the Water-Insect or Gnat," Hooke writes in part as follows: "This little creature, described in the first Figure of the 27. Scheme, was a small scaled or crusted Animal, which I have often observ'd to be generated in Rain-water; I have also observ'd it both in Pond and River-water. It is suppos'd by

some, to deduce its first original from the putrification of Rain-water, in which, if it have stood any time open to the air, you shall seldom miss, all the Summer long, of store of them frisking too and fro." He then describes the larva, its shape, bristles and tufts, its motion and characteristic position of hanging head downward. The pupa also is described, its "horns," its movement in the water and the emergence of the adult. He says nothing about the use of the siphon of the larva and he did not see the eggs of the gnat, but supposed that they were dropped into the water by the adult. Another idea was that the eggs were brought down by falling rain, and still another that "whether multitudes of those other little creatures that are found to inhabit the Water for some time, do not, at certain times, take wing and fly into the Air, others dive and hide themselves in the Earth, and so contribute to the increase both of the one and the other Element." He concludes by discussing nut insects, and galls and their contents.

Concerning the flea, some of his observations are as follows: "The strength and beauty of this small creature, had it no other relation at all to man, would deserve a description. For its strength, the Microscope is able to make no greater discoveries of it then the naked eye, but onely the curious contrivance of its leggs and joints, for the exerting that strength, is very plainly manifested, such as no other creature, I have yet observ'd, has any thing like it; for the joints of it are so adapted, that he can, as 'twere, fold them short one within another, and suddenly stretch, or spring them out to their whole length." He then describes its leaping motions—its polished body and armor and its proboscis.

In observation 54, before outlining the shape, feeding methods, etc., of the louse, Hooke writes entertainingly,—"This is a Creature so officious, that 'twill be known to every one at one time or other, so busie, and so impudent, that it will be intruding it self in every ones company, and so proud and aspiring withall, that it fears not to trample on the best, and affects nothing so much as a Crown; feeds and lives very high, and that makes it so saucy, as to pull any one by the ears that comes in its way, and will never be quiet till it has drawn blood."

As to the feet of flies and their ability to walk on substances including glass, he says, in observation 37, after describing the pulvilli and their small "bristles" which he likens to the wire teeth "of a Card used for working Wool,"—"hence the two Tallons drawing the feet forwards, as I before hinted, and these [the pulvilli] being applied to the surface of the body with all the points looking the contrary way, that is, forwards and outwards, if there be any irregularity or yielding in the surface of the body, the Fly suspends it self very firmly and easily, without the access or need of any such Sponges fill'd with an imaginary gluten, as many have, for want of good Glasses, perhaps, or a troublesome and diligent examination, suppos'd. Now, that the Fly is able to walk on Glass, proceeds partly from some ruggedness of the surface; and chiefly from a kind of tarnish, or dirty smoaky substance, which adheres to the surface of that very hard body; and though the pointed parts cannot penetrate the substance of Glass, yet may find pores enough in the tarnish, or at least make them." Hooke's "imaginary gluten" was later found to be the secretion of glandular hairs.

Hooke's difficulties with some of his specimens are indicated in observation 49, on the ant, wherein he writes, "This was a creature, more troublesom to be drawn, then any of the rest, for I could not, for a good while, think of a way to make it suffer its body to ly quiet in a natural posture; but whil'st it was alive, if its feet were fetter'd in Wax or Glew, it would so twist and wind its body, that I could not any wayes get a good view of it; and if I killed it, its body was so little, that I did often spoile the shape of it, before I could throughly view it: for this is the nature of these minute Bodies, that as soon, almost, as ever their life is destroy'd, their parts immediately shrivel, and lose their beauty." He finally placed it in "a drop of very well rectified spirit of Wine," and then laid it on paper until the spirit of wine had evaporated, after which he easily adjusted it with a pin.

In observation 45 on "the great Belly'd Gnat or female Gnat," he wrote in part, "One of these Gnats I have suffer'd to pierce the skin of my hand, with its proboscis, and thence to draw out as much blood as to fill its belly as full as it could hold, making

it appear very red and transparent; and this without any further pain, then whilst it was sinking in its proboscis, as it is also in the stinging of Fleas: a good argument, that these creatures do not wound the skin, and suck the blood out of enmity and revenge, but for meer necessity, and to satisfy their hunger. By what means this creature is able to suck, we shall shew in another place.”

Hooke's descriptions are confined, for the most part, to what he could see through his microscope and frequent references are made to the drawings. They are not comparable of course to present-day descriptions. The complexity and interrelationship of parts had not yet been studied and the terminology was meager. Woodruff states “Although the work is replete with singular anticipations of the discoveries and inventions of other workers in various branches of science, the biologist's interest is chiefly in Hooke's application of his improved compound microscope to the study of plants and animals which paved the way for the more special, profound, and methodical studies of the contemporary students of nature. In the *Micrographia* are clearly described and figured for the first time the ‘little boxes or cells’ of organic structure, and his use of the word ‘cell’ is responsible for its application to the protoplasmic units of modern biology. It is fair to say that the influence of the *Micrographia* permeated the sciences in various directions and the illustrations of microscopic objects were copied for nearly two centuries.”¹

ANTHONY VAN LEEUWENHOEK
(1632–1723)

During Leeuwenhoek's life-time, the Netherlands declined from the height of commercial and maritime supremacy to a second-class power, but it is doubtful if Leeuwenhoek knew what was happening. Changing political and economic conditions held no interest for him, but grinding lenses and looking through microscopes did. Starting as a dry-goods apprentice in Amsterdam and later operating his own store at Delft, he found himself, at the age of forty, without money or reputation, but through

¹ *Scientific Monthly*, 1921, p. 260.

the influence of relatives he managed to get the job of janitor to the sheriff's office in Delft. Although one usually associates janitors with furnaces, brooms and mops, Leeuwenhoek was not that kind of janitor. He had a political janitorship and, as a result, plenty of leisure time which he devoted to the grinding of lenses and to the microscopic examination of innumerable small objects.

He examined the structure of fruits, seeds, deciduous trees, conifers, etc. He was the first to make a microscopic study of yeast cells, to correctly describe red blood corpuscles, to discover bacteria, Hydra, protozoa, micrococci, to see crystals in plant tissue, to satisfactorily demonstrate the capillary flow of blood, to give a satisfactory account of plant lice and their development, to see the eggs of ants, and to make many other observations which eventually led to more refined work by later investigators. Insects came in for a fair share of his attention. He described insect eyes, trachea, wing scales, the sting of the bee, gall insects, cheese maggots, cochineal insects, etc., and often made observations on their life-histories.

Leeuwenhoek had few scientific acquaintances, but he was fortunate in having the friendship of Regner de Graaf, who made him known to the Royal Society of London, which printed most of his papers in their Transactions (numbers 94-380), and made him a fellow in 1680. He also sent letters to the French Academy. Many of his papers were accompanied by drawings made, not by him, but undoubtedly under his supervision.

In the Philosophical Transactions for 1673 (T. 8, No. 94, pp. 6037-6038) under the title, "A Specimen of some Observations made by a Microscope, contrived by M. Leewenhoeck in Holland, lately communicated by Dr. Regnerus de Graaf," Leeuwenhoek writes as follows.

"2. The *Sting* of a *Bee* I find to be of another make than it hath been described by others. For I have observed in it two other stings, that are lodged within the thickness of the first sting, each having its peculiar sheath.

"3. Further I observe, on the Head of a *Bee* before, two *artus* or limbs with *teeth*, which I call *Scrapers*, conceiving them to be the organs wherewith the *Bee* scrapes the Waxy substance from

the Plants. Besides, I find two other limbs, each having two Joints, which I call *Arms*, wherewith I believe this Insect performs its work and maketh the Combs. Moreover, there is also a little Body, which I call the *Wiper*, being rough and exceeding the other Limbs in thickness and length, by which I am apt to believe the Bee wipes the Honey-substance from the Plant. All which *five* Limbs the Bee, when she doth not work, knows curiously to lay close under her head, in very good order."

"4. As to the *Eye* of the Bee, which I have taken out of the Head, exposing its innermost part to the Microscope; I find, that the Bee receives her light Just with the same shadow as we see the Hony-combs: Whence I am prone to collect, that the Bee works not by art or knowledge, but only after the pattern of the light received in the *Eye*."

Leeuwenhoek's odd supposition that the hexagonal honeycomb cells were due to a sensation received from the hexagonal eye facets of the bee was confuted by Swammerdam in his "Biblia Naturae." In a later number of the Transactions (No. 97, pp. 6116-6118, 1673) Leeuwenhoek's figures, which should have accompanied paper number 94, are printed together with explanations.

In 1694, the Transactions (T. 18. No. 213, pp. 194-199) carried, "An Extract of a Letter from Monsieur Anthony Van Leeuwenhoek to the Royal Society, containing the History of the Generation of an Insect, by him called, The Wolf. With Observations on Insects bred in Rain-Water, in Apples, Cheese, &c." In this, Leeuwenhoek states that,—"The Wolf is a small white Worm armed with two red Sheers or Teeth at the fore part of its Head, wherewith it bores and feeds on the Grains of Corn, and makes its way through Wood it self." He then describes its feeding habits in wheat, the emergence of the adult moths in his glass tubes, eggs, scales, etc., in fact most of the article is devoted to the "wolf," which is apparently one of the grain moths. He claims that fair control was got by fumigation with sulphur.

Another paper (Philos. Trans. 1698. T. 20. No. 240, pp. 169-175) is entitled, "Part of a Letter from Mr. Anthony van Leeuwenhoek, F.R.S. concerning the Eyes of Beetles, &c." Among

other things he states: "Amongst the rest, I have, last Summer, shewn to several English Gentlemen, the Multiplicity of Eyes that are to be seen in the *Tunica Cornea* of a Beetle, that is called the Eye." "This Sight was very strange to the said English Gentlemen; because, that if one will reproach a Man with Blindness, or Dimness of Sight, they use to say in English, *You are as Blind as a Beetle*, because they reckon a Beetle to be Blind." He then describes what he saw under microscopes and the results of his dissections of the eyes of flies. He also writes,—“The Paws of these Flies, Chiefly that Side they run withal, are plentifully provided with Hair-like Parts, wherewith they know to run upon Polished Glass, more than any other sort of Flies. I have cut off Paws, and fixed them before the Magnifying Glass, for to shew the Tools wherewith they are able to fix themselves to the Polished Glass, and so to run up.”

In “A Letter from Mr. Anthony van Leeuwenhoek, F.R.S. concerning some Insects observed by him (sic) on Fruit Trees,” (Philos. Trans. 1700. T. 22, No. 266, pp. 659–672), he deals with plant lice on quince, plum, currant and cherry, and refers to his letter of 1695, wherein the parthenogenesis of aphids is mentioned. He was responsible for much new information about these insects, their cast skins, the excretion of honey dew, parasites, etc.

Miscellaneous observations on gall insects and cheese maggots are contained in “Part of a Letter of Mr. Anthony Van Leeuwenhoek, F.R.S., concerning Excrescencies growing on Willow Leaves &c.” (Philos. Trans. 1701 (1700 err. typ.) T. 22. No. 269, pp. 786–792).

Leeuwenhoek studied the life-history of fleas, from the eggs to the adults, and found that Father Kircher was wrong in attributing their origin to dust and debris. Concerning the mouth parts of fleas, he says in “Microscopical Observations on the Structure of the Spleen, and the Proboscis of Fleas. By Mr. Anthony Van Leeuwenhoek, F. R. S.” (Philos. Trans. 1706. T. 25. No. 307, pp. 2305–2312),—“This Scabbard of the Flea is divided into 2 parts, and each of them has a Cavity like a Canal, in order to contain the Sting when those Parts are close shut together; but that which was most remakable (sic) to me was, that each of

those hollow Parts, that compose the Sheath or Scabbard, was compos'd of Parts like the Teeth of a Saw. These Teeth, I conclude, are so made as to indent one within another when the Sting is in the Sheath, in order to hinder the opening of the same at any other time than when the Flea would make use of it: Yea, that which is more, we discover'd at the end of each of the Scabbards 3 Teeth standing out, which I judge was for no other end than to shut within one another."

What appears to be a wandering account of several species of Dermestidæ, with notes on his feeding experiments, descriptions of larvæ, and habits of the beetles, etc., is found under the title, "Additional Observations upon the Production of Mites, &c. In a Letter from Mr. Anthony van Leeuwenhoek, F.R.S." (Philos. Trans. 1712. T. 29. No. 333, pp. 398-415).

Ants, spiders, cochineal insects, body lice, etc., were also the objects of his investigations, and many additional facts were uncovered. Although he sometimes drew wrong conclusions and never exhausted the possibilities of any of his subjects, and although he did not have the patience of Swammerdam, he was responsible for many worth-while discoveries. Doctor Becking² believes that erratic, illiterate, uncultured and unimaginative Leeuwenhoek obtained his place in the same group with Swammerdam and Malpighi by "reflection." Becking states, "It is only the genius that can synthesize a vast group of disconnected facts under a general law, where the truthful observer only can describe and catalogue. In that respect Leeuwenhoek did not reach the mental level of a taxonomist; his descriptions were not catalogued." However, Leeuwenhoek was a pioneer in a hitherto unexplored field. There was no incentive for him to dig deeply in any one place. A hundred things called to him at once and he went from one to another. If he had not wasted part of his time in making 527 gold, silver and brass microscopes, and if he had worked in order in a much smaller field, and if he had been a college graduate, he might or might not have contributed more to science. He was simply himself. He did what he did because it pleased him and because it was interesting.

² Sci. Mon. Vol. 18, pp. 547-554.

His place among the immortals is due to his microscopes and to his curiosity.

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